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ABSTRACT

Fiber optics communication technology is a potential competitive alternative to coaxial cable and shielded twisted pairlines as a wide-band communications medium. Pilot demonstrations by public institutions such as the health care delivery system can test the application of this new technology. Fiber optic networks may have the potential to be cost effective and to allow for expansion of communication use, but implementing fiber optics communication may require interdisciplinary effort as well as national policy and regulatory decisions. (CH)

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OPTICAL INTRABUILDING AND INTERBUILDING DISTRIBUTION NETWORKS

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I. Introduction

Communications using carrier frequencies corresponding to the visible and near infra-red wavelengths is now possible over low-loss, extremely small and flexible dielectric waveguides known as fiber optics. Fiber optic communications technology has emerged from research demonstrations and some vigorous analytical studies over the past five years to a potential competitive alternative to coaxial cable and shielded twisted pair lines as a wide-band communications medium. A number of manufacturers now have low-loss optical fibers available and are making rapid progress in developing sturdy cables, splicing techniques, and connector devices. Further, device manufacturers report steady progress in producing reliable, long-life sources and detectors. In all of these technology areas, a primary emphasis is to reduce costs. The cost of optical fiber and associated components may well be competitive with, or less than, the existing wireline installations for intrabuilding and interbuilding services within the next 2 to 5 years.

At present, the cost of optical fiber cable is approximately equal to that of wide-band coaxial cable when compared on a channel-kilometer basis. To place this cost factor in perspective, the copper alone in a typical twisted pair shielded cable costs about $1.50/kilometer. Functionally, this metallic cable can be replaced with a single glass fiber cable in which the cost of the glass is approximately $0.50/kilometer. Assuming comparable packaging costs for the two cable products (this now appears feasible), the mature cost of fiber optic cable should be less than that of copper cable. Of course, the price of copper will continue to climb as our sources of this precious metal become more costly to procure and extract. One must also pay a premium for dedicated, specially conditioned lines to obtain necessary freedom from noise, cross-talk and electromagnetic interference. It seems reasonable to expect that a procurement of optical fiber by any of several possible users (e.g. U.S. government, foreign PTT, large telephone or telegraph corporation, CATV network, . . .) will provide the incentive

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to develop the necessary facilities with economies of scale adequate to bring material costs down and make fiber cables cost competitive with current twisted pair wires. Thus, projections over the next five years or so indicate that fiber optic cables represent a challenging solution to many interpanel communication connections.

The added capacity of the fiber cables will make possible significant expansion of communication facilities, for example, a large building complex which may be a modern hospital, a large office building, a high-rise apartment complex, or senior citizen housing development, or complexes of the above. Within such new or existing institutional complexes, many wide-band telecommunication services (including video, facsimile, computer, business, automated monitoring, etc.) can be developed on the basis of added capacity, and not be constrained by limitations of narrow-band networks. The application of large-scale-integrated circuit technology, along with the semi-conductor devices required for transmit/receive interface terminals, make possible the design of very inexpensive communication links. Sale price of production transmit/receive modules capable of operating up to 100 megabits and distances up to 100 meters are projected to be about $50.[2] Graded index fibers can extend these systems to kilometer lengths.

FOC is a "glamour technology" with much promise. It is being supported with considerable private research and development funding domestically. It is being vigorously pursued by several of our primary competitors internationally, notably, Japan, United Kingdom, Germany, France, and Canada. Why should this technology be discussed as part of a policy research conference? What are the consequences of assuming that this technology is a healthy part of the telecommunications industry and that it should be left on the back burner to develop on its own as part of the free enterprise system? Cannot this technology "move into the marketplace" primarily as a function of "market" needs alone? These are <u>hard</u> questions!

II. Discussion

Let us consider fiber-optics technology as an examples of the innovative process, namely the translation of invention into products and services to support commerce and to meet national needs. As an enabling technology and service, telecommunications is becoming more strategically important particularly as information transfer requirements become more essential to meet world economic and societal needs.

Current U.S. R&D expenditure on FOC technology is approximately $100M per year. The major part of these expenditures supported by our large telephone industries, namely Bell Laboratories, GTE and ITT. The potential pay-off for these efforts in the short-haul trunking networks between metropolitan area central offices is one of the primary forcing functions, accounting for the strong participation of the carrier research laboratories. Full-scale field tests are in progress by AT&T[3] in Atlanta and GTE[4] in California. The Japanese[5] have already operated a 123.49 Mb/s optical fiber system over a distance of 2 km. They have designed and reported[6] on a 400 mb/s system. Thus, working demonstrations of complete systems which will be operating in a hybrid, transparent mode with existing telephone plant installations are underway with production and use forecasted for the 1980's. The CCITT has recently established a Joint Working Party, SGO, to commence international standardization. We may conclude that plans and progress are well underway for incorporation of this new technology in the main stream telephone applications.

Many near-term applications of fiber optic communications not involving long distances or high bit rates, have emerged to meet military requirements. Examples are data bus applications for shipboard and aircraft communications and control, undersea cable communications, rapidly deployable communication links, and planning for replacement of existing multi-pair cables in many applications. Industrial applications where the special properties of this technology provide a unique solution to vexing or difficult problems are also emerging. Figure 1 is a partial list of these special properties.

These special properties lead to such non-military applications as:

a) Inter-panel connections for computer-to-computer, controlled systems, test instrumentation links, etc. to eliminate troublesome interference and ground loop problems.

b) Connections to provide electrical isolation in areas exposed to power surges such as electrical power generating stations, electrified mass transit, medical intensive care instrumentation, etc.

c) Applications requiring low cross modulation technology, for example cable television main feeders.

d) Connections where existing duct systems (street and building) are inadequate for expanded cross-section of conventional cables.

FIGURE 1. SPECIAL PROPERTIES OF FOC.

- IMPULSE NOISE ELIMINATION
- LOW RF RADIATION
- IMMUNITY TO ELECTROMAGNETIC INTERFERENCE
- IMMUNITY TO CHEMICAL AND OTHER HOSTILE ENVIRONMENTS
- SIZE, WEIGHT
- BANDWIDTH
- LONGER TRANSMISSION DISTANCES
- ELECTRICAL ISOLATION
- LOW CROSS-TALK LEVELS
- POTENTIALLY LOWER COST

e) Connections in locations with hostile atmospheric or environmental contamination such as salt spray.

These specialized applications solve a particular user need where cost is not necessarily a primary concern and where the user is generally supported by a fairly sophisticated engineering support capability. Such specialized applications will not lead to large business and will not necessarily come to public attention, or need they be the concern of policy planners.

The main stream non-military competitive applications of FOC lie in adopting it for use in delivery of services of the type mentioned in the introduction. OT is currently attempting to quantify the nature and magnitude of the current information processing industry. These economic studies tend to point up the surprising extent and pervasiveness of the information processing underway in our current society. If we consider only the industries associated with the delivery of social educational and health services, we can see extensive public need for improved delivery methods aided by technology. These service industries desperately need the capabilities promised by such advanced technologies as FOC, but planners and participants are not necessarily aware that this technology can provide help. While the market potential is there, tremendous intertia to change is there also, necessitating extensive education, demonstration, and experience as prerequisities for acceptance of this and other new products. The major emphasis of FOC industries looking toward these public service applications is directed toward this education process - attempting to get the attention of decision makers who must ultimately "bite-the-bullet" about investing in this new approach.

One portion of this industry which has received much public attention and Federal support is health care delivery, now the largest single industry[7] in the U.S., representing about $90B per year. There has been much emphasis on the use of telecommunications in health care delivery, even to the adoption of the term "telemedicine." Some excellent reports and reviews of the current status, pilot programs, and degrees of success in the application of telemedicine are available[8,9,10]. A review of these efforts reveals many factors common to the introduction of any new technology. A partial listing of such factors is shown in figure 2. A primary reason for public support of pilot demonstrations is to satisfy item one, that of establishing the claimed advantages. The introduction of new technology in operational

FIGURE 2. SOME ITEMS IN THE ADOPTION OF ANY NEW TECHNOLOGY.

1. ESTABLISH PROOF OF CLAIMED ADVANTAGES (PERFORMANCE, COST, EASE OF MAINTENANCE).

2. COST OF CHANGES IN LOGISTICS SYSTEM TO SUPPORT OR UTILIZE NEW ITEMS.

3. PROPER CHOICE OF MANY ALTERNATE ITEMS FOR GIVEN APPLICATION.

4. NEW TECHNOLOGY UPSETS EXISTING PLANS FOR ACQUISITION OF EQUIPMENT THAT USES OLD TECHNOLOGY.

5. NEW TECHNOLOGY MAY REQUIRE SOME SORT OF CULTURAL CHANGE AMONG USERS IN ORDER TO ACCEPT IT.

6. MECHANISMS FOR IMPLEMENTATION OF TECHNOLOGY IN PRODUCTION - PUBLIC RELATIONS EFFORT TO STIMULATE MARKET - CUSTOMER SERVICE ORGANIZATIONS THAT CAN SOLVE TRAINING PROBLEMS - MODIFICATION OF THE NEW TECHNOLOGY TO RESPOND WHEN IMPROVED UNDERSTANDING OF CUSTOMER NEEDS IS AVAILABLE.

systems require careful planning for logistic support or the demonstration will fail and the participants will revert to tried and proven methods. Choice of alternatives - such as new and different terminal devices for a given application - is stimulated by the introduction of new technology. This is especially important in telemedicine pointing to the need for placing the demonstration projects in teaching hospitals to ensure the widest possible exposure. The free enterprise system, fundamental to our capitalistic society, rests upon the establishment of satisfactory business-customer relationships. Unless the established supplier is diligent in introducing new technology, a competitive pattern quickly develops.

Among the fundamental issues in telemedicine requiring much further exploration are the sociological or cultural changes which impact professional-paraprofessional-patient relationships when the telecommunication system is introduced into health care delivery. The ultimate acceptance of technological change requires the development of confidence and satisfaction on the part of the users in interfacing with the system. Finally, clear mechanisms for utilizing the technology, including appropriate customer service organizations are required.

Application of telemedicine to health-care delivery points up many institutional problems, requring close association and mutual support between communications engineers and the people being served (professional-paraprofessional-patient). These people-system interface problems are not necessarily dependent upon remote offices or terminals for their investigation and evaluation. Such institutional problems may well be carried out in a single building or an adjacent building complex. The total communications needs of such institutions can be addressed as an institutional problem. These include: multichannel, two-way video, high-resolution facsimile, physiologic sensor, monitor and control system, medical record and data processing traffic, inventory and business data processing, entertainment and instructional TV, and many similar services. Assimilation of all such institutional communication requirements, the development of operating protocols, the demand access assignment procedures, and the priority and reliability considerations are challenging communication network design problems which may be addressed by many competitive entrepreneurs. Solutions for one institutional application may well apply to others. The emphasis on such institutional network designs must be directed toward the needs of the people which it serves.

III. Conclusion

This paper opened with a brief description of an emerging communications technology which has received widespread attention. We have attempted to indicate the status of the development

and application of this technology in the mainstream communications industries. We then make the recommendation that this technology be considered for early pilot demonstrations by public institutions suggesting a health-care delivery institution as a typical building complex for testing the technology's applications on the basis of an enabling, functional part of a publicly supported program. The resultant demonstration program would not necessarily require fiber optic networks, but we postulate that future fiber optic networks will be more cost effective and provide capacity for expansion of institutional communication traffic. Such expanded, assimilated institutional communications traffic will be a requirement for providing future economies of scale for long-distance communications whether that be by satellite with dedicated small earth terminals or high-capacity switched terrestrial networks. The potential interdisciplinary effort required for implementation of such institutional pilot systems may well require future policy and regulatory decisions. We present this as an example of an innovative process for consideration by this policy conference.

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